This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

95.

A TREATISE
ON
VENTILATING
AND
WORKING COLLIERIES.

BY

J. A. RAMSAY, M.E.

Newcastle-upon-Tyne:
ANDREW REID, PRINTING COURT BUILDINGS, AKENSIDE HILL,
AND 12, COLLINGWOOD STREET.
LONDON: LONGMANS & CO.

1882.

COLLIERY VENTILATION
AND
WORKING.

A TREATISE

ON

VENTILATING

AND

WORKING COLLIERIES.

BY

J. A. RAMSAY, M.E.

BIBLIOTHECA
APR 1882
BODLEIANA

Newcastle-upon-Tyne:
ANDREW REID, PRINTING COURT BUILDINGS, AKENSIDE HILL,
AND 12, COLLINGWOOD STREET.
LONDON: LONGMANS & CO.

1882.

186. h. 121.

NEWCASTLE-UPON-TYNE:
ANDREW REID, PRINTING COURT BUILDINGS, AKENSIDE HILL.

TO

Joseph Whitwell Pease, Esquire, M.P.,

OF

HUTTON HALL, YORKSHIRE,

THE

FOLLOWING PAGES

ARE

(WITH HIS KIND PERMISSION)

RESPECTFULLY DEDICATED

BY

THE AUTHOR.

INDEX.

PAGE.
Introduction 5
Chapter I.—Natural Ventilation 11
„ II.—Ascensional do. 14
„ III.—Friction of Air 17
„ IV.—Projecting and Laying out Workings 24
„ V.—Consecutive Working of different Seams 37
„ VI.—Furnace *v.* Mechanical Ventilation 41
„ VII.—Recording the Ventilation of Collieries 45
„ VIII.—Popular Ideas on Colliery Ventilation 48
„ IX.—Summary and Suggestions 53
Conclusion 58
Appendix.—The Thornley Air Crossing, Plate XI. 60
Water-Gauges, Plate XII. 61
Recording Work done by Ventilating Engines, and Form of Book 65
Rules for Measuring Air in the Mine, and Form for Registering in the Office 65

INTRODUCTION.

Ventilation may be defined as a constant stream or movement of the atmosphere we live in. In the primeval age man did not know, neither did he materially require, the art of conducting the ambient fluid in which he moved beyond the boundary of his daily perambulations. Living in caves or dens, having nothing but the lowest order of artificial surroundings, almost in a state of nature: natural law supplied his wants or worked its will. We can dimly picture a confiding savage squatting in a cave or den labouring to light a fire with which to prepare his simple meal, perhaps using the wing of a fowl he has secured for his repast to fan the flickering flame he has obtained by the friction of sticks. Then after eating his meal, animal like, he lies down upon the floor of his den to sleep; already the deadly gas from the fire of wood has commenced to spread itself over the floor: the fire smoulders and burns, and at length it is smothered in the products of its own combustion. Meanwhile our poor savage sleeps on, inhaling the poisonous vapour, and at last unconsciously passes into that sleep which knows no waking. He is missed and sought for by his tribe, who at last track him to the den, where he is found to all appearance in a quiet sleep. One of his fellows stoops down to arouse him, and whilst so doing inhales the deadly carbonic acid gas, which speedily lays him prostrate beside his dead companion. Peering through the gloom another cautiously bends his body to see what is the matter, when he quickly feels something catching his breath, and a smarting in his eyes. He rises in dread, alarms his companions, who, seized with superstitious fears, fly from the fatal spot. After a time they return with their chief and then find their two comrades in their last sleep of death. The destroyer has, however, gone, but the impression remains that the god of caverns will not have his sanctuary invaded with impunity.

At a later period we can picture a group of warriors feasting in the chimneyless wigwam, their mirth and comfort are marred by the cloud of smoke confined within their narrow dwelling, it makes their heads ache and their eyes smart: when an accidental falling in of a part of the roof gives vent to the cloud, and the warriors immediately find relief. They watch the heated column pass curlingly upwards and away to the distant cloudland, and from that time reason bids them provide an outlet for smoke, &c., from their dwellings.

From these rude and uncivilized sources we have the first germs of our present system of ventilation, viz.: a fan to agitate and throw off the air, and a furnace to give a large heated column of the same elements.

The necessity for ventilation must have existed since the earliest days of man, but the growth of the science has been very slow indeed, as the earliest written record we have of it is not more than three hundred and fifty years from our own time.[1]

At the commencement of this century the fan, bellows, air-pump, furnace, and waterfall had each its advocates,[2] so that we have really nothing new in our present system of ventilation except in the improved construction of any of these appliances.

The fan was considered the most effective apparatus in the days of Agricola; it was then constructed in round or square wooden boxes, and driven by hand, wind, or water power. Machines driven by steam were only known in that day as philosophical toys, and the best ventilators were only capable of drawing air from passages four hundred yards in length. Some idea may be formed as to what has been done during the last half century when it is stated that both fans and furnaces are now constructed to draw over two hundred thousand cubic feet of air per minute, and this from galleries several miles in length. But notwithstanding these huge appliances which eject their millions of cubic feet of air per hour, and the vastly increased depth and extent of underground operations, it is very questionable whether the means or adaptations for utilizing these improvements towards saving life have kept equal pace.

---

[1] Georgii Agricolæ, De Re Metallica, libra xii. Froben, Basil 1557.

[2] Numerous English writers at the commencement of this century, and on the Continent. See German edition of Villefosse, complete, with large atlas of plates, presented to the North Staffordshire Institute of Mining and Mechanical Engineers, by the author, in February, 1880.

In recent years the theory of mine ventilation, which has for its object the rendering harmless and sweeping out of all noxious gases and vapours, has received the earnest and most devoted attention of our ablest and most renowned engineers, and the public interest in this branch of the mining profession is abundantly shown in the various Reports of the Parliamentary Commissions which have enquired into and reported upon the state of Mines, and by the Annual Reports of Her Majesty's Inspectors of Mines. Treating upon this vital subject there are also numerous theoretical and practical papers, published in the Transactions of the North of England Institute of Mining and Mechanical Engineers, and similar associations. As a treatise on the friction of air and its constituents, and the volume and density of gases met with in mines, the author thinks this a favourable opportunity of drawing the attention of students to the valuable work of the late Mr. J. J. Atkinson.[1]

In view of all which has been written on this subject, and the ponderous ventilating machinery which has of late years been erected, the writer submits that the means are at hand by which all noxious gases may be rendered harmless; that the frequency of the appalling calamities which from time to time startle the public *will* not arise so much from the want of means to obviate them as from the non-application of known laws or mechanical inventions; failing which, in spite of the most skilful and unremitting attention of the persons in charge, there will always be a risk of a recurrence of the dreadful calamities with which mining communities have of late been too familiar.

---

[1] Mr. Atkinson's treatise is published by Andrew Reid. Printing Court Buildings, Newcastle-upon-Tyne.

The author approaches the subject of the paper with some diffidence, yet with a hope that it will introduce a discussion on practical ventilation generally, and induce other members of the profession to publish short papers on ventilation applied under difficulties, and noting therein any unusual phenomena that may occur. The exchange of ideas on such questions is not only a fulfilling of the object of the various scientific institutions now happily established in all the principal mining districts of this country, but it has a direct tendency to stimulate and quicken the application of the best means for working mines in the safest and cheapest manner, and so enabling the workman to render, without risk to health or life, "*a fair day's work for a fair day's pay*"—thus cheapening the cost of labour, as without fresh air the man cannot exert as he ought his natural energy nor do the work for which he is paid.

VENTILATING AND WORKING COLLIERIES.

CHAPTER I.

NATURAL VENTILATION.

The air we breathe is a gaseous fluid of great elasticity, it gravitates towards the centre of the earth and therefore has weight and pressure, it is capable of almost infinite expansion and compression, it absorbs heat from the earth, and from the sun's rays. This heat rarifies and causes it to ascend, carrying with it moisture in the form of vapour and various other gaseous products of animal and vegetable life, of combustion and decay. The ascending volume of air is replaced by a supply from colder regions; the heated air cooling as it rises its vapour is condensed into water, and in this devaporised condition passes into the upper and colder currents of the atmosphere. By this beneficent and incessant movement and change, the atmosphere in which we live and move becomes winnowed and washed from the impurities it has gathered from miscellaneous sources whilst in contact with the earth.

This natural arrangement is essentially of the first importance to animal and vegetable life, to keep which in a healthy condition, there must be ample room for the re-distribution of the products of respiration. In every confined space such as is used for the abode, occupation, or amusement of man, or for mews or conservatories, special arrangements must be made for the constant replacement and carrying away of the air thrown off in the breathing of animals and plants.

The same law which causes a rise or fall of the atmospheric currents over the free face of the earth, operates also below its surface. Suppose there are on the side of a mountain, two caverns of different altitudes and some distance apart, and that they have a subterranean connection, a current of air will generally be passing along the connection from one to the other; but the direction of this current will be subject to the variation of the temperature of the atmosphere, the cold invariably displacing the warmer current. As a rule, in warm weather, the air will be ejected from the lower level, and in cold weather from the higher. At every change there will be a short suspension of the ventilation, and when the temperatures above and below are equal, there will be a complete stagnation.

This principle of natural ventilation is often applied to the working of mines of small extent, but for mines of large extent the power of a few degrees difference in the temperature at the surface is too feeble, under the most favourable circumstances, to be at all depended upon, and it becomes imperative to apply means, artificial or mechanical, to insure a voluminous current and to keep it travelling in a regular circuit. As most colliery establishments have their downcast shafts and upcast shafts within a short distance of each other, and about the same surface altitude, then where such is the case it is evident that the natural conditions under which the shafts are found will be about equal, and it is highly improbable that a current of natural ventilation will find place at all, but should one by any chance set in, it will be of the most feeble kind.

Whilst thus depreciating the value of natural means of ventilation, as insufficient for the maintenance of the necessary supply of pure air in mines, it must not be understood that accessory or artificial means are to proceed on other than the principles and lines above laid down in speaking of natural ventilation: on the contrary, it must be the object of the practical colliery manager so to avail himself of these principles, and so to supplement their action, that, by means of exhausting fans at the top, or of rarefying furnaces at the bottom of the upcast shaft, he shall accelerate the ascending current of heated and vitiated air, in order that pure and cool air may be more rapidly brought down to supply its place in the parts of the workings where needed.

CHAPTER II.

ASCENSIONAL VENTILATION.

The end and aim of mine ventilation is a constant displacement of the atmosphere throughout all chambers and passages in the mine, and as this displacement cannot be effected without the application of a force, it becomes the first duty of the engineer to provide the means, not only to overcome the inertness of the volume, but to impart such a velocity as will enable it to accomplish its mission. Of the various powers applied at the present time, those of the centrifugal fan class appear to be in highest favour, but as these machines yield only about fifty per cent. of useful effect, it is not difficult to foresee that a higher stage of perfection will be attained, especially when we consider that machines of the varying capacity class have barely entered into the contest, and in useful effect, rival the power of the centrifugal machines. It is, however, more to our present purpose to write of air in the mine, irrespective of the moving power.

In the preceding chapter it was shown that the natural order of ventilation was for a warmer atmosphere to be replaced by one of lower temperature, it therefore follows that the air on descending the pit ought to be conducted to the most remote regions to be ventilated before entering the return passages, as in the intakes of all extensive mines, at a certain distance from the shaft, there is obtained a zone of almost invariable temperature, beyond which the changes are derived solely from the operations in the mine. Then as each degree of added temperature imparts a greater buoyancy to the air, it also follows that where the return air courses are made to ascend, the best results will be had without reference to the class of power applied.

Mines yielding fire-damp are especially susceptible to ascensional ventilation, as from the nature of this gas, which is equally affected by gravitation, pressure, and expansion by heat as atmospheric air is, and in the latter of which it will float with the same buoyancy as soft wood (unwater-logged) will float in water.[1]

The following instance, taken from a colliery in the North of England, is a striking example of the benefit to be obtained by the heated air and gas evolved being drained ascensively from the higher reaches of a district of workings instead of returning almost parallel with the intake. The seam of coal averaged about three feet in thickness, and dipped nearly four inches to the yard. On reference to Plate I., it will be seen that the whole work was followed up by the broken. The seam was rather prolific in gas, which was, under ordinary circumstances, kept under by the ventilation applied, but it had happened after the drawing of a jud or juds at night, after coal work, that large quantities of gas were emitted out of the goaf, and to such an extent on one occasion that it drove back on the intake, and some hours afterwards was found by the night master-shifter at the bottom of the engine plane marked C on the Plan. The gas slowly receded or was rather driven forward by the intake without in any way disturbing the normal ventilation, and the district was "cleaned" and in usual order for the back-shift on the following day. Gunpowder was not used in the district, and at night the only workmen employed were stonemen repairing ways or air courses.

---

[1] The weight of air being 1, fire-damp is 0·562, or a trifle over one-half only of the weight of atmospheric air.

In the original setting out of this district of workings, now many years ago, the long barrier A B was left to keep under control any water which might come from the rise, and of which a large quantity was known to exist, it was thus standing as it were between two evils, one of which (the gas), was positively against it, whilst the other was on full enquiry found to be dreaded only in a remote degree. It was, therefore, determined to break the barrier on the rise side, with a view of draining the gas ascensionally from the goaves marked M and N, and a thirling D E was made. The most satisfactory results followed. Before this thirling was made gas could often be traced by the edges of the goaves; after it was made in the region of the workings it was rarely found.

This illustration shows very forcibly that a district working under some risk was placed, by the alteration, comparatively free from danger, and it is worthy of remark that for years after the holing was made, the gas served out very strongly, and had to be diluted before passing over the air crossing at F. Fresh air for this diluting process was allowed to scale through the stoppings on the low side of the rolleyway, and when the split reached the point G, it joined the return from the high district, and all visible trace of the gas was lost. About twenty men and boys per shift were employed in the district below the barrier, and they were served with from ten thousand to twelve thousand cubic feet of air per minute, of which a good part found its way with the gas through the holing at T.

CHAPTER III.

ON THE FRICTION OF AIR.

THE theory of circulating air in the passages of mines has been most ably argued by the late Mr. J. J. Atkinson, who says, "The pressure required to overcome the friction of air increases and decreases in exactly the same proportion as the area, or extent of the rubbing surface, exposed to the air increases or decreases; and *varies* in the same proportion as the *square* of the velocity of the air increases or decreases; so that a double velocity of air in the same air way, meets with a *double double* or fourfold resistance; a treble velocity meets with a *treble treble* or ninefold resistance; and a velocity of four times as great gives rise to a resistance of four times four, or sixteen times as great. In the same way half a velocity meets with one-half of a half, or one-fourth of the resistance; one-third of the velocity encounters only a third part of a third, or one-ninth of the fraction and so on."

On the thirty-second page of his Treatise on Ventilation he gives a table showing the comparative amounts of pressure expended upon creating velocity in the air, and upon overcoming the frictional resistance it meets with in mines. The pressures due to velocities being those due to the final velocities at the tops of the upcast shafts. The table may be shortly summed up as follows:—

	Pressure in Air Column due to Friction.	Pressure in Air Column due to Velocity.	Total Pressure Employed.
	Feet.	Feet.	Feet.
Hetton	94·5	5·5	100
Haswell	91	9	100
Tyne Main	87·3	12·7	100
Mean result	92	8	100

"Friction, then, arising from the air rubbing against the top, bottom, and sides of the airways in mines, is really the greatest obstacle to be overcome by the ventilating pressure or power; the force required to put the air into motion, apart from friction, being very small in comparison, at least in a large majority of cases, particularly in coal mines, which generally require a much more energetic ventilation than is necessary for the salubrity of metallic mines."[1]

The following case, owing to the peculiar circumstances under which it was working, is interesting, as showing a very considerable pressure of air lost by friction. It occurred in August, 1879, at a colliery in a midland county. The air was transmitted in ordinary iron tubes 12 inches in diameter. But before entering into particulars a brief account of the general arrangement of the shafts, and connections therewith, will better enable the reader to comprehend the case, and Plates II. and III. will illustrate it.

There were two large shafts, numbered 1 and 2, Plate II. No. 2 was in coal work, and was the upcast, and was found with a well-constructed, well-built Guibal Ventilator, 40 feet by 12 feet, and a winding engine equally well-built and well-constructed. The Seams VI. and VII. were opened, and coal work was being vigorously carried on in both seams on each side of the shaft (see Plate IV.) The intake to the workings of this pit was by the Seam VI. from No. 1 Pit. In the night hours, No. 2 Pit shaft was being sunk to ventilate the lower seams conjointly with No. 1 Pit, which was then down to the depth at which it was intended to win the rise coal of the lower seams, and a level stone drift was driven to a distance of 153 yards intersecting the lower measures (see Fig. 1, Plate II.) In a contrary direction on the opposite side of the shaft, a stone drift on the same level had been driven and intersected the Seam VIII. at the point B, and a heading was being driven in the coal in direction of No. 2 Pit (see Fig. 2, Plate II.)

---

[1] The author begs to thank the Executors of the late Mr. Atkinson for the permission given to make the above Extracts.

No. 1 Pit below the Seam VI. was dependent entirely upon piped air for its ventilation. The stone drift was ventilated by three tubes 12 inches in diameter, entering behind a brick brattice (or partition), only a few yards from the bottom of the pit, and these tubes were carried up the shaft and entered the intake of the Seam VI. This arrangement, although giving a uniform and constant current of air, was hardly sufficient to keep the drift in a state for men to work in, but it was certainly very much better ventilated than the heading in Seam VIII., which had a special arrangement of iron pipes from the surface to the face, and it is from this arrangement that the instance of loss of pressure of air by friction is taken.

About twenty-five yards from the top of No. 1 Pit there was an ordinary ventilator four feet in diameter, having its orifice discharging into a wooden box from which three sheet iron tubes, 12 inches in diameter, were taken continuously down the shaft into the face of the heading in the Seam VIII. It was intended to take particular notes of the result of this method, but the short time it was permitted to work under a new management, did not admit of this being done. By a casual observation made by the manager on the morning just before he went down the pit for his first shift, he found the ventilator driven by a long belt from the fly-wheel of an engine worked constantly for that purpose, and going about 250 revolutions per minute. An attached water-gauge showed a pressure of 2¾ inches. On going into the Seam VIII. he found the ventilation very sluggish and warm. In the drift the tubes were carried from the shaft along the roof of the arching to the Seam VIII., and were then conducted by the left-hand side, one over the other into the face of the heading; at the ends a small sensation of air was discharging from the pipes at the top and bottom, but in neither was there sufficient to turn the fan of the anemometer; out of the middle pipe there was more, as the fan of the anemometer did turn, but not with such briskness or motion as to enable the velocity to be taken. This was the normal condition of the ventilation of the heading. On returning towards the shaft, the hooker-on was calling for all men to come out because the fan belt had broken, and finding that this breakage was of frequent occurrence, provision was made for improving the system. The belt was ordered to be taken off and the fan dispensed with, the workmen instead of riding to bank to await repairs were at once employed to break the connection of the tubes at the Seam VI., and to turn the end of the bottom part into the intake of No. 2 Pit. This alteration reduced the length of tubes by more than two-thirds, and reversed the air in the Seam VIII. At the face end of the tubes there was then sufficient air being drawn to give a fair motion to the fan of the air meter in all three pipes, but the quantity even yet was not sufficient to keep the heading free from gas.

At this stage a chamber was formed in a segment of the shaft at the level of the drifts, and from it a culvert of about 5 feet inside area was built by the side of the arch wall leading into the Seam VIII. where the 5-inch brick wall was carried up to within 18 inches of the roof. At the shaft the three tubes were disconnected and entered into the chamber, and the same was done at the end of the culvert in the Seam VIII., and the wall closed round, and to the roof. The easement thus given made a further improvement in the ventilation of the heading, no trace of gas was then to be found until the ends of the tubes were reached, and they were about four yards from the face.

As the time necessary to sink No. 2 Pit down to the Seam VIII. would allow this heading to stand until a holing was made out of the stone drift on the north side into it, and thus enable the ventilation of No. 1 Pit to course round in one current, and all pipes and brattice (which at the best are very objectionable about the bottom of the pit), from the shaft into the holings to be dispensed with, the means to this end were at once undertaken.

An extra air tube was entered into the air chamber and connected to the return of the stone drift on the north side of the shaft. A north-east heading (see Plate III., Fig. 1) was driven in the Seam IX. for a distance of thirty yards, and from the face a stone drift was driven in a south-easterly direction up into the Seam VIII. and holed into the heading (21st October, 1879). Whilst this work was being done, doors were erected as shown at D D (Fig. 1, Plate III.) All the air tubes and the brattice on the north side of the pit were now fully connected with the air chamber, and the culvert on the south side disconnected with it and the doors D D closed. The ventilation was then completed as far as it could be made with iron tubes in the shaft only, until the final holing was made on completion of the sinking of No. 2 Pit down to the Seam VIII.

As incidents of face airing, the continuation of the heading in the Seam VIII. gave two good examples. With the quantity of air at hand, after the completion of the holing from the Seam IX., it was thought that by inserting the three tubes into it and close bratticing round (Fig. 2, Plate III.), the air would sweep up to the face and clear it of gas before returning in the tubes. For working the heading this was the most desirable arrangement, as it kept the tramway and jig arrangement free from doors; but it did not answer at all, the air appeared to turn sharp in at the ends of the pipes, and so slow was the diffusion of the gas with the air, that at a short distance from them there was a marked feeling of higher temperature and a complete stagnation took place, indeed, at only four or five feet from the pipe ends, the gas would explode in the lamp. Before any work was attempted in the face a door was erected on the outbye side of the holing, as shown at D, Fig. 3, Plate III., and the air tubes applied behind the door packing. The mouth of the drift was cleared and the door closed, the pipes now blew the air up instead of drawing it down as in the preceding case. This arrangement thoroughly swept the face and kept it free from gas until the heading holed into the shaft (2nd December, 1879), a few days after the contractor had finished his work.

To insure an uninterrupted ventilation in completing the heading, the door at D, Fig. 3, Plate III., was kept closed, and the coals got out of the heading were teemed down the drift into a hopper placed in the Seam IX., where they were loaded into tubs and led thence on the level way to the shaft.

From the foregoing cases the writer submits that the general practice of drawing air through mines in the main or trunk air-ways is the correct one, and that in the case of short distances in forming pillars, &c., the face will be best ventilated by making the air "*blow out*" of the lesser aperture instead of "*drawing in*," and that the rule holds good whether by piped air or ordinary brattice, and whether to the dip or to the rise.

The method by which the winning of this No. 1 Pit was made differs from the general practice in the North of England, where a segment of the shaft would certainly have been bratticed off, if not for the whole depth of the pit, certainly from the Seam VI., and a holing would have been made round the bottom of the pit, leaving sufficient siding room on each side before any work so extensive as the long crutt, or the heading in Seam VIII. towards No. 2 Pit, had been attempted.

CHAPTER IV.

PROJECTING AND LAYING OUT WORKINGS.

THE Plate, No. IV.,[1] has reference to the workings in the Seam VI. and the Seam VII., as found in August, 1879, with a projection for the further development of the workings and ventilation, as made in the month of October following.

In the winning of the seams the coal about the shafts was very much opened and broken, and it was with great difficulty and expense that the separation of the fresh from the return air currents could be maintained. The dates marked at intervals on the plan will show the points obtained during the six months of the management referred to (Aug. to Feb.) It will be seen by the plans that the workings had a rise of 28 degrees to the north-west, and that without special provision the whole of the return currents would have to be drawn down the bank and make their exit by the shaft sidings. Without reference to the peculiar circumstances under which the winning openings were made, and the broken state of the coal, this was, to say the least of it (especially with the seams at such an angle), not the acknowledged correct method by which to enter the whole of the returns from a large pit's workings into the upcast shaft, because, however remote the most dreadful catastrophe the miner has to guard against may be, the manager's first duty is to do everything possible to avoid accidents of all kinds, and to make such provision as will minimize the effect of even the smallest explosion of gas. This can be best done by keeping the returns as far distant as possible from the intake, and making them debouche well up into the upcast shaft, and in steep measures to follow the rule of having the upcast as far as possible from the downcast and, where the natural formation will permit, to the rise of it.

---

[1] The example of recording the ventilation, as given in the Appendix, has reference to this plan.

Without entering upon a disquisition as to the method of working the seams it is necessary to remark in passing that the system of work laid down was "longwall," and very properly so. There were main level roads to the east and west in each seam, and the coal was only being worked to the rise: a rib of coal with holings at intervals was left between the intake and the goaf or gob. The workings with the blue tint show the intakes commencing at No. 1 Pit, and the red tint shows the air returning to No. 2 Pit. The workings in the Seam VII. are shaded round with yellow, and were in part subjacent to the Seam VI., but only on the west side. Through the obtuse manner in which the seams were approached there is an apparent complication about the shafts, not only in the working ways but in the ventilation. To show distinctly which are the main rolleyways in this region a dotted line is made on the plan in the centre of the cutting, and these roads are all on or about the same horizontal plane, and, as before remarked, the coals were all sent to bank by No. 2 or the upcast pit. At the time of making the change in the management the whole underground work was closing in in the most lively manner, the air-ways about No. 1 Pit were very scant, and many short cuts direct to the upcast: the greatest vigilance was called for from every one having places of trust or responsibility. The workings were curtailed and more centralized, hence there was very little diminution in the pit's output of coals: there were no new faces of longwall opened on the west side in either seam, and further extension in the east of the Seam VII. was on the advice of one of the ablest men in the country discontinued, so that the only line open for development was on the east side of the Seam VI.

The area of coal to be worked from the west side being of small extent the system of ventilation was found to be equal to the requirements, but not so on the east side, from which very nearly the whole supply of coal from this pit (No. 2) was, for a period of a year or two at the longest, to be worked. The fresh air entered upon the rolleyway immediately on the inbye side of the separation doors marked D D, and as the arrangement then stood, the whole of the coals had to be led through these doors. The air was conducted inbye by the rolleyway in the usual manner; the jig-brows, as will be seen by the plan, ran right down to this rolleyway, and they were served with air direct, each jig-brow or gate-road having two or more swing canvas doors through which the air was allowed to scale, and the last thirling took the remainder of the whole. The various splits so formed united at the face and streamed back to the upcast shaft in two currents, one on each side respectively. Owing to the difficulty in keeping the returns open, the remaining air at the innermost thirling (or holing) was not always as much as might be desired; indeed on two or three occasions, when the leading places made a little extra gas, they were stopped because of the insufficiency of air, and until the air-ways were made of ample sectional area it was determined not to commence more gate-roads but to confine the coal-work to what was open and driving the leading levels. During this period there were well-nigh as many men employed in the gateways as in coal-getting, which made matters very trying for shareholders, directors, and all in charge; but the order was to make everything safe, and *this order had the first and best attention.* After the most careful cogitation of the situation the improvement of the plan (Plate IV.) was discussed and *the projections approved of*, and it was determined, 1st—To drive a slant numbered I. on the plan; by this road a very large proportion of the coals worked would reach the shaft without having to pass through the separation doors; 2nd—To drive an intake for the air from the point U so that it might be taken in-bye independent of the rolleyway; 3rd—To lay the advancing work upon a broader base. These works were commenced at once, and were progressing in February, 1880. In the new work of the east levels it will be seen that the gate-roads are laid on at intervals of forty yards, giving a twenty-yards lift on each side, and in the rib separating the intake from the goaf there is a holing at every twenty yards. As the work progressed it was the intention to stow every alternate thirling, leaving the one opposite the gate-road open, and to place a frame regulator in it so that a proper quantity of air could be served to each gate-road or jig-brow. This arrangement compared with the work shown from the separation doors to No. 2 slant, as worked without a separate level for the intake, would avoid the great interruption to the ventilation caused when the jigs were working by the tubs running through the canvas doors, which at best, owing to the situation they were placed in, formed only a very imperfect separation between the intake and return. Comparatively the improved method would give an almost absolute control of the ventilation; whilst the saving of expense in the brattice cloth account would be no inconsiderable item, if such were to be taken into account upon so important a matter. It was also determined to form a connection between the east and west side workings about the line X, Y, Z, and on the point Y being reached, to improve the intake of the return air into the upcast shaft, a stone drift with a rise of about 18 inches per yard was to be driven up into it, and as soon as practicable the same line of drift was to be continued down into the five-feet seam to be ready to drain its return air courses when the workings reached that point. These drifts will be best seen on reference to the section, Plate II., and had they been completed the foulness of the goaves would have debouched about 170 feet above the heads of the men and boys employed at the hanging on.

Having given these practical illustrations, the author will now enter upon the speculative section of this part of the subject.

The question as to the best method of establishing a good and safe colliery is a very wide one, and subject to many circumstances. There are three essentials, each having a very wide field. The first is the ground to operate upon; the second the means to operate; the third the operator. The points given are, however, fair subjects for discussion, because to make a place a success to know what to avoid is the first great step. The surroundings of the colliery (Plates II., III., IV.) were somewhat exceptional. As an example of failure through mistaken notions at the beginning, amateur engineering, and haste to realise profits, a better illustration will not be easily found.

With the examples before us two very natural questions suggest themselves—

1st.—Could the works not have been laid out so that the ventilation would have been at once constant and effective?

2nd.—Were there any reasons why the arrangement of the air-ways and the working-ways should be laid out in so complicated a manner about the shafts?

To the first the only reply is an affirmative one. The reply to the second has, since the work shown on Plan, Plate IV., been amply made by the concern itself, which struggled out of vitality; therefore, in deference to all the influences which caused the work to be done as it was, it will be found more instructive to consider how a good and safe colliery might have been established upon similar ground—supposing the railway plant, screens, &c., to have been in proper position.

The Projection Plate V. is made on the strike of the measures, and in actual level differs very slightly from Plate IV., the great point of difference being that the hanging on is made at the Seam VI., which would give the colliery a direct advantage in the immediate working of the coal won. The quantity of coal which can be won by this level is a strip less than by drifting between the seams as was done in Plate IV. (and Section Plate II.). The projection is also made from the original cast as to which should be the upcast shaft, as it is properly placed on the basset side of the downcast. Where there are two or more shafts, it is contrary to the general practice to make the upcast a winding pit when one only is required for that purpose, but it was the intention of the preceding manager to make this pit (No. 2) work from the upper seams only, and that No. 1 Pit, the downcast, was to do the great bulk of the work from the lower seams, which as a rule are more prolific in gas than the upper ones; with such an aim in view, the arrangement was in ordinary practice.

The Plan (Plate V.) under notice is laid on for the same system of ventilation as the improvements projected for the Plan, Plate IV., the special features in it being immediately about the shaft. Work is commenced at once in the seam, and all stone drifting across the measures to other seams is postponed until the ventilation is fully established. The strike of the measures in this locality was well known before the time of sinking these two pits, therefore, directly they were down to the first seam intended to be opened, work could have been commenced on the strike, either by the plan under discussion or some other plan equally well digested, the operations being carried on in something like the following order:—In the near sides of the shaft the holings *a*, *b*, *c*, *d*, *e*, would be formed, on completion of which the ventilation would be fairly established. The thirlings *b* and *c* ought to remain open, or under regulation for the passage of air, the others, as the work extends, should be very carefully stowed with the rubbish got in making height or forming the shaft sidings. Every thirling so stowed ought to have two stoppings of masonry, one open to the intake and about three yards within the thirl, the other towards the high end. To prevent the down-rolling tendency of the stowing, each of them ought to be built on a curve, as shown on the plan. Each pair of levels on the strike would be driven forward simultaneously, also the headings *f f* and *g t* to the full rise, on each side of the upcast shaft. On reaching the point H they would be turned right and left and continued to form the shaft pillar in conjunction with the headings I, J, K, L, driven up out of the main levels on each side of the shaft. On completion of the shaft pillars, the longwall work could be fairly started at M and N. From the point H a stone drift, rising 18 inches per yard, would be driven up into the upcast shaft, and on the completion of this drift, the upcast being provided with a ventilator, the ventilation of this seam would be fully established. As soon as the flank faces M and N are up into position, the removal of the pillars on the high side of the shaft pillar can be commenced, and the centre face of work fairly opened, the gate road *g t* being kept as the permanent incline for this central work. The two main slants marked O, P, Q, R, must be had up in time so that the line may be kept up through the goaf simultaneously with the advancing work. By this steep incline marked *g t*, and the two slants marked O, P, Q, R, at the very least one-half of the seam won at this depth can be landed contiguous to the shaft, without having to be passed through any separation doors, and after the first coal adjacent to the level is extracted, by manipulating cross gate roads into the slants, the whole of the remaining coal above level in this seam can be so worked.

On regular work being established in Seam VI., commencement may be made to win the other seams. In downward progression the Seam VII. comes first, consequently we cut into the floor, on the rise side of the Seam VI., commencing operations as follows:—On the intake end of the thirling *e* commence a stone drift rising at about a $\frac{1}{4}$ inch per yard; soon as this drift is ready to enter close work below the floor of the Seam VI., having kept width sufficient; build two substantial side walls, and turn an arch leaving an inside sectional area of not less than 50 feet. Directly over this arch, which had better be built a few yards within the close drift, and having its crown closely built up, the main stopping ought to be built, which, owing to its peculiar situation, must be of extra strength. On completion of the stopping, the thirle in Seam VI. must be carefully packed, and about three yards from the return end of it, the second stopping to be built and the stowing completed. Should the roof not stand well it will be advisable to turn the drift away, build the arch, &c., whilst the shaft siding is being made, and the same can with more certainty be said in the turning away of the main working level in the direction of the Seam VII. The intake level will then be driven forward until it intersects the Seam VII., which will be about the point marked S on the plan; at this point stop the forward progress and turn a heading away in the coal passing under the heading *f* in the Seam VI. When this is done commence the main working level, upon the same method as described for the intake; at the foot of the heading *f*, and continue it across the heading already driven in the Seam VII. From the left-hand side, in a recess formed for the purpose, sink a small staple down to the heading; on holing a complete circuit will be formed for ventilating this winning. The main working level will now be continued till it intersects the seam and simultaneously the intakes for the fresh air will have been formed by headings on each side of the drift; soon as this main drift intersects the seam, the working levels will be turned right and left, holing into the intake headings already formed, the work will then be laid out on each side as by the system Plate VII. By this arrangement the whole of the leading from this seam can be done without having to pass through any separation doors, thus insuring an uninterrupted ventilation during coal work. The first holings ought to be made with great caution, for if there be any gas in the rise headings which have been driven for the intakes, the pressure of fresh air will drive it with full force over the lights of the men working in the main level, and so on to the shaft. To avoid this danger stoppings with some scale way ought to be built a short distance past the ends of the first thirl, and an abundance of fresh air must be sent up the staple, in fact more than will go into the face, so that when the holing is made the accumulated gas will be drawn slowly off and be met with plenty of fresh air to render it harmless on passing the top of the staple.

On completion of these cross measure drifts, the drifters or stone men can be further employed in continuing the line of the upcast drift from the point H in the Seam VI., its centre face of longwall being sufficiently far advanced not to damage the drift in its progress down into the Seam VII., the stones made in driving it to be stowed on the top of the arch at the mouth of the main drift in the remainder of the heading *f*, and in the thirlings made between it and the incline *g t*. The completion of this drift for the return air will fully establish the ventilation of the Seam VII., and its goaves will be cleared of their foulness without it having to travel by the level to the upcast shaft, and as the main level drift intersects this seam on the outside of the shaft pillar, after holing the slope drift, the longwall work can be put into active operation at once. Two diagonal gate roads (or slants) might be laid on, each of them serving into the same siding within the level cross measure drift.

There is a grave objection to working different seams of coal within the same zone simultaneously, where the intermediate strata are not sufficiently thick to hold in check the crushing influence which follows goaf settlements or weightings, and although the author says "the longwall work can be put into active operation at once" on the opening of the Seam VII. being completed, he submits that excepting under a proper system it is bad mining to work seams of coal having the operation of one seam over or under those of another, and that such ought to be avoided. At the same time the exigencies of trade may positively demand a supply of different qualities of coal to meet the requirements of the market, and it becomes a matter of vital importance for a colliery to work two or more seams simultaneously out of the same pit. By the method in front of us, we divide the working of the colliery into three great districts, in which three seams may be worked simultaneously without their several workings materially encroaching within the zone of one or the other, because in any case where the influence of workings is felt from one seam to another, if these workings be over or under each other, that trouble and expense will follow is almost as certain as day follows night. By a system of working districts successively in the different seams this may be entirely avoided.

After treating of the recovery of the third seam we will return to this subject.

On reference to the diagram (Plate VI.) it will be seen that were the measures to follow uninterruptedly the line of slope at which they are found, a continuation through the rising measures, of the line of the level drift which intersected the Seam VI. at X would also intersect in due course the whole of the lower seams, and the coal above that level could be worked out of the same drift. So also a drift driven horizontally through the dipping measures would intersect the whole of the upper seams; such a drift would commence at the first thirling marked *v* east of the shaft on the plan, Plate V., which will have been carefully stowed and stoppinged. On reaching a point marked *v* on the south-east side of the intake, form a recess on the east side of the drift, and at the end of it sink a staple down to about the middle height of the intake air course, and drive through into it. As this staple will be for the permanent ventilation of the upper seams to be worked out of this level it ought not to be less than eight feet in diameter, and as this side of the pit will give the easiest ventilation, the quantity of air passing will require regulating. It will also be found advantageous to drive a slope drift up into the seam about the point marked *w*, and to hole back over into the upcast shaft in the seam as shown by the dotted lines, *w x*. Before completion of this holing doors must be erected at D D, ready to be closed soon as the holing is made. The driving of the drift can be continued until the seam is cut and the holing *y z w* made in the seam, which is now ready for laying open the work in any direction except in the shaft pillar, one side of which ought to be formed about the line of the strike of the measures where the drift intersects the seam.

If there is an abundance of air and an entire absence of gas the Seam V. can be recovered without driving the slope stone drift *w*, as the whole length from the top of the staple round by the thirling *y z* in the seam will not exceed two hundred yards. In drifting under similar circumstances the practice in the North of England is to divide the single drift by a proper brick brattice, which although costly in the first instance is very much to be recommended because of its stability, and the reliance which is to be placed upon it in forming a good separation between the intake and the return. If the drift is going through a good hard stone a good separation can also be formed of boards about an inch in thickness, nailed longitudinally upon props set for the purpose, and having a small overlap, so that in the pointing, part of the mortar will run into and set between the deals. Trumpet or piped air ought to be limited to such places as those which cannot be reached by ordinary bratticing, unless the pipes are of a good size, and the air is served in at some pressure.

The foregoing projections are made to illustrate generally the workings of steep measures, but the system is equally applicable to flat seams. The work is also shown on a broad side to the strike of the measures, which will not always be on the proper line for obtaining the coal to the best advantage. These points, and the distributing or splitting up of the main air currents, are collateral matters which the manager will have no difficulty in working into position to suit the varying circumstances of different localities, or, in other words, the engineer must identify himself with the nature of the ground he has to operate upon, and the work he has to perform.

CHAPTER V.

CONSECUTIVE WORKING OF DIFFERENT SEAMS.

Referring to the subject of working several seams simultaneously, it must be taken as an axiom that one seam worked at a time, within a given area, is the simplest practice, and that any multiplication of the number of seams worked in the same area will, from the nature of all mining, increase the difficulties in working in an unknown ratio. In most cases where more than two seams must be in operation at the same time, it will be found that the best results will follow their being worked in turn down over, but there are cases in which an upper seam will work better after the seam below is worked, the cause of this difference is owing to the nature and thickness of the intermediate rocks.

In a colliery, with which the author was connected, in the North of England, two examples came very prominently under his observation. Four seams were being worked as follows:—

No. 1 at 170 yards in depth or about.
„ 2 „ 192 „ „
„ 3 „ 212 „ „
„ 4 „ 234 „ „

In the first case No. 3 Seam had been worked, and No. 2 was in work. The intermediate strata consisted mostly of strong grey metal and white post. No. 2 was in the state termed "*Winded*," caused through the seam below having been worked; it was very hard to work, and did not yield such a quantity of round coal as when worked with the seam below it entire.

In the second case No. 4 Seam had been worked, and No. 3 was in work. The intermediate strata consisted mostly of soft blue and grey metal; it worked much easier and produced more round coal than when worked with the seam below entire.

No. 2 had as a roof a soft blue metal of considerable thickness. No. 3 had a variable thickness of grey metal followed by thick bands of white post.

When it is determined to work more than one seam at a time, two very important questions must have mature consideration before the several seams are divided into the districts by which they will be worked:—

1st.—The nature and thickness of the rock intermediate to the seams to be worked.

2nd.—The demand of the market as to quality and quantity which the colliery is intended to supply, and in what proportion the seams to be worked will meet the demand.

Having ascertained these points, the service required from each seam must then be carefully estimated, as that upon which the greatest demand is likely to be made ought to have the favoured position, the others following in their grade.

For illustration suppose we take the three seams open per Plan, Plate V., and it is estimated that the Seam VI. must supply twice the quantity of the Seam VII., and that the Seam V. will only be required to supply half the quantity of the Seam VII. The Seam VI. and Seam VII. are of equal thickness, and the Seam V. only half the thickness of either of them. The intermediate strata are such that the operations of the Seam VII. must be kept far apart from those in the Seam VI. The Seam V. cannot be profitably worked whilst the strata below it are unsettled by workings in the Seam VI., which in its turn becomes very unsettled as soon as the workings in the Seam V. begin to spread over its gateways. Under these circumstances the Seam VI. must open in a region to be occupied solely by itself, and the Seam VII., being also the lowest of the series opened, must develop in a decidedly contrary direction, and in another section of the same region as that allocated to the Seam VII., the Seam V. will be opened, or the thickness of the intermediate strata may be such that it will withstand any damaging influences that the working of either of these seams might have one towards the other.

Having found that fifty-seven per cent. of the pits produce must be supplied from the Seam VI., we at once allocate the whole of the region west of the incline G T and two gate-roads on the east side of it for its workings. For its service it will have one main level, and the slant or diagonal on the south-west side, and the steep incline *g t.* Twenty-eight per cent. is only required from the seam VII., and for its service it will have one main level, and a diagonal on the east side. As the entrance to this seam must pass under the south-east corner of the allotment to Seam VI., on the projection being made for the workings of the Seam VII. (See Plan, Plate VII.) it may be considered advisable not to work the Seam VI. more than is necessary to form the air-ways and incline *g t* over the alotment of the Seam VII., and the same may be said of the Seam VII. towards the Seam VI. The workings in the Seam V. will be laid on to follow the goaf made in working the Seam VII.

When the time arrives for the workings of Seam VI. to enter upon the eastern region of the colliery for its service, the same steep incline will be used, and the level and diagonal on the south-east side must be formed. During this period it will be found advisable to move the operations of the Seams V. and VII. to the western part of the colliery, and a further recovery of the Seam VI., or another seam of equal quality must be considered.

CHAPTER VI.

FURNACE *VERSUS* MECHANICAL VENTILATION.

In taking a retrospect of the last fifteen years, the great improvements made in the mechanical ventilation of mines almost forces one to the conclusion that the days of furnace ventilation of deep mines, or indeed any which evolve noxious gases, are numbered. The power of the furnace appears to have reached its maximum, whilst that of mechanical ventilation is only in its infancy, yet in effect the latter has already exceeded the best performances of the former.

The maximum power of a furnace by rarifying the air appears to be about 1,000 cubic feet per minute per foot area of the upcast shaft, with a density of between two and three inches of water-gauge. An objection to the furnace can also be raised in the simple fact that explosive mixtures may pass over the fire. Even where these mixtures can be controlled and discharged into the upcast shaft by dumb drifts there is still very great risk, as the following incidents will prove:—At Washington Colliery a furnace, which stands about five yards from the bottom of the upcast (which is about 92 fathoms in depth) was lighted during the time of changing the ventilation from Lemielle's to Guibal's system, when the heat from it burnt the wood packing out of a pulley socket placed on an iron frame within the cupola at the surface. Shortly afterwards, under similar circumstances, sparks from the furnace settled upon a wooden stopping placed about three yards within the arched way leading to the fan case and set fire to it, the furnace being at the time driven at its full power. It will be thus seen that at any place subject to outbursts of gas it will be unsafe[1] to discharge the return air into the upcast even by dumb drift, unless the mouth of the drift is at such a distance from the fire as to preclude the possibility of sparks in a state of incandescence reaching it. This distance must be considerably over 200 yards.

It is evident that the efficacy of mine ventilation, either by artificial or mechanical means, depends entirely on the power applied. By furnace less fuel in a deep shaft will give a higher ventilating power than the same quantity will do in one of less depth, but the maximum power can be reached in each case. It is simply a question of power and the quantity of fuel consumed.

In working a colliery where there are several seams, mechanical ventilation has a great advantage over the furnace, as the return air courses may then take their direct lead into the shaft, giving the great benefit of an increased number of air-ways debouching into the upcast. Rarefaction of the return air would, under similar circumstances, render a furnace in each of the seams necessary; otherwise a concentration of the different air currents would have to be made, and this could not be done without expense and loss of power.

If a colliery ventilated by furnace and requiring the maximum power of rarefaction evolves such a quantity of gas that it must be conducted into the upcast shaft by dumb drift, the system can only be worked under the most imminent risk.

---

[1] That sparks in a high state of incandescence will explode gas is confirmed in the Select Committee's Report of 1835.

1st.—In the event of a spark in a state of incandescence reaching the mixture and exploding it.

2nd.—The explosive current entering the shaft at a much lower temperature than the ascending column might easily lead to the formation of a *natural brattice, which once established would soon balance the heavier column of air in the downcast shaft*, and if it did not at once cause an explosion by driving the dangerous mixture down to the furnace it would quickly arrest the general ventilation of the mine and throw the pits working into a state of stagnation. Under such a condition it is difficult to conceive how an explosion could be avoided.

With this conviction the writer submits that it ought to be made compulsory that all collieries evolving gas of an explosive nature in large and dangerous quantities should be provided with the most approved mechanical ventilators. Colliery proprietors would certainly profit by such a course.

By the introduction of mechanical ventilation into fiery mines, another risk not often taken into account would be avoided. Most collieries have a goaf not far distant from the shafts, and it may be known that as a rule the edge of this goaf is perfectly free from gas. As to what is above is mere conjecture—probably a large space filled with gas, resting very quietly, rising and falling only very slowly—say a few feet for each inch change of the barometer. With an exceptionally low barometrical pressure a small quantity may ooze out, but as the glass rises it returns to its normal limits. The glass falls again, and then an extra heavy shot; perhaps one blown out produces a heavy reverberation or big sound wave; a more than usual concussion is felt far away from where the shot is fired, and the disturbing influence causes the gas nestling in the rookeries of the goaf to burst through the humid stratum upon which it was resting; buoyantly it floats on to the furnace, and as quick as lightning the messenger of death and destruction is let loose, gathering force as it spreads and speeds away.

CHAPTER VII.

RECORDING THE VENTILATION.

Next in importance to the ventilating power itself is a full and reliable register to record the distribution of the air in the mine. There may not perhaps be a uniformity in the forms of registration, but as this is desirable, it is worthy of special notice in any paper on ventilation.

Wind gauges are now instruments of precision compared with what they were in the last generation, and by them the quantity of air passing in any gallery of a mine can be accurately ascertained.

Mechanical ventilators may be looked upon as miners' wind gauges on a large scale, the effect depending upon the size and velocity at which they are worked.

In preparing his forms of registration the author began at the fan engine house and continued on through the various places of measurement in the mine. The speed of the ventilator is recorded every three hours in a book kept in the engine house. The person whose duty it is to measure the air in the mine takes an account of the work done by the ventilator during the time he has been making the measurements, and records the whole results in the book kept for the purpose in the colliery office. This book gives direct reference to the points where the air is measured in the mine by reference to an index letter marked on the working plan. A water gauge[1] ought to be fixed as near as possible to the principal of these points so that the difference in the density (the drag) between the intake and return currents may be registered.

In order to illustrate this method the author gives an example of a few days' registration taken from the records of the ventilation of the mine, per Plan, Plate IV., and copies of the instructions[2] written in the fore pages of the books.

To make a harmonious register from the measurements and observations strict rules must be followed, both in handling the anemometer and making entries in the books. The pointer of the anemometer ought not to be run round the dial to enable the measurer to commence at the cyphers of 100, but just as the work in the engine-house is recorded continuously from the attached counter so ought the revolution of the anemometer to read continuously from one measurement to another.

The rules and forms are very slightly altered from what the author introduced at Washington Colliery about seven or eight years ago.

Mines ventilated by furnace or any other means than machinery on the surface could have the primary work of the power applied registered equally well by the foregoing method. All that is required is to attach a manometer by a connecting rod and crank to an ordinary windmill, which for purposes of comparison would fully answer the purpose. Small windmills are very often made by the furnacemen as a pastime, and placed in the main airway near the furnace; but these are of course too small and not adapted for any crank attachment for working an engine counter (or manometer). What is wanted is something larger and of more substantial construction. A windmill with six or eight vanes, about 15 or 18 inches long, by $3\frac{1}{2}$ or 4 inches wide, correctly set by a plumber, and erected by a good mechanic who could attach the counter, will give a good index to the general state of the ventilation; in fact, for comparative purposes it will be equivalent to the revolutions made by the ventilator on the surface, and the work as shown by this windmill counter, ought to be registered upon the same principle. It is very advisable to have such windmills, fitted with counters also, placed in each of the principal intakes of any mine, whether ventilated by fan or furnace, and the velocity of the current, as shown by these windmills, ought to be frequently registered by any one in charge in passing. Such monitors, open to the inspection of all passers, would certainly make those who are responsible for the ventilation more active in their efforts to increase and utilize the life-giving, life-saving element.

---

[1] See Appendix, note B, Water Gauges.

[2] See Appendix, note C.D.E.F.

CHAPTER VIII.

POPULAR IDEAS ON COLLIERY VENTILATION.

Since the commencement of mining in this country there has perhaps never been such a voluminous correspondence in the public press on colliery explosions and ventilation as during the latter part of last year. The subject has been most liberally dealt with by all classes of the community. For the benefit of non-professional readers it may not be out of place to make a passing remark on one or two of the prevailing ideas.

That deserving the first attention is the "*Wetter sohle*," about which so much was written in the *Western Mail*, and afterwards copied into other papers. The "*wetter sohle*," or to clothe the term in simple English, "*the air level*," is, the writer thinks, common to all coal-fields where steep measures are worked. In all probability it is the oldest method we have in England for ventilating colliery workings. The system may be defined as a utilization of the levels of an old pit to ventilate or act as the "*return air course*" for a newer and deeper pit to the same seam, or in case the same pit is sunk deeper, and the seam intersected from the under side by an under-level or cross-measure drift, then on the new workings holing into the old level, the latter becomes the "*wetter sohle*," or the "air level."

The writer first observed this system in operation at the Whitehaven Collieries, where it must have existed from a very early day. These collieries were amongst the first in the country to apply mechanical ventilation in preference to the furnace, and the ventilators were naturally applied to the shafts nearest to the workings requiring to be ventilated. Owing to the inclination of the coal beds the recent pits had to be sunk to a very much greater depth to reach the seams worked formerly by the old pits, and the latter were at the time the writer alludes to used as furnace or upcast shafts. The furnaces having been superseded, the old air levels may not now be in existence for the simple reason that they are no longer required.

In the North of England the same system is in common use, although the seams are comparatively level, the cross-measure drift finding its equivalent in staples connecting the lower with the upper seams Thus at Washington Colliery of the four seams worked the main return air currents are kept in the uppermost but one of the seams, it being impracticable to have them in the topmost of all. Where the top seam is worked the returns from it either descend by a slope drift or a staple to the seam below.

Plate VI. fully illustrates the method of air levels. Supposing the whole of the coal in the Seams VI. and VII. to have been extracted above the horizontal line X Y, or that more coals are wanted out of these seams than can be supplied from that level, then let the cross-measure drift A B be continued until it intersects them.

In order to establish the ventilation for the recoveries a pair of places (or headings) should be driven in the seam up into the original levels on the horizon X Y, which will then become the "wetter sohle," or "air levels," to the workings in the same two seams on the horizon A B and upwards.

As an example of working and ventilating steep measures in Germany the author begs to insert in this paper a short extract from a leading work on German Coal Mining, and to give the plate to illustrate the text—see Plate VIII., upon which a few remarks in English are made—so that at the same glance the method will be better understood. The following is a translation of the extract alluded to:—

> The ventilation of the work is easy. The fresh air enters by the cross-measure drift, and streams left and right in the air channels to each working place, then comes up and returns by the tramway, through the thirling and the upper cross-measure drift, and is drawn through another division of the shaft out to-day. By this method a considerable distance can be driven. Should the air become feeble, a thirling is driven to shorten the way the air current has to travel, so that the air re-attains the whole of its activity.[1]

In this case the "wetter sohle" is the next higher cross-measure drift to the one last opened for work. In larger collieries advantage may be taken of the upper drifts, and air-ways maintained through the goaves as is generally done in this country.

Another and favourite idea of newspaper correspondents is to ventilate collieries by a system of pipes, and to blow the air under high pressure into the workings.

From whatever point this method is observed it seems utterly impracticable and inimical in the direction of thorough ventilation. In effect it would be nothing more or less than laying a pipe within a pipe and forcing the purifying current through a passage that needs no ventilation, *and it would be thus conducted in a close pipe past the very object for which it is sent into the mine*, and if discharged into the working face it must return to the surface either by the regular returns of the mine or upon the exterior side of its original conduit. To discharge a large volume of air by such means would undoubtedly become a source of real danger, because in case of an overflow caused by any temporary stoppage in the returns instead of the dangerous atmosphere being absorbed quietly, it would be forced by the air pressure behind into the working ways, leading to no end of trouble and danger.

---

[1] Die Wetterführung in den Bauen is leicht. Die frischen Wetter fallen durch den untern Querschlag ein, strömen links und rechts in die Wettercanäle der beiden Abbaustrecken, kommen oben auf die Förderstrecke zurück, strömen durch ein Abhauen, durch den obern Querschlag und ziehen durch eine andere Abtheilung des Schachtes zu Tage aus. Man kann auf diese Weise bedeutende Längen auffahren. Werden die Wetter matt, so treibt man ein Abhauen und verkürzt den Weg, den der Wetterstrom zu machen hat, so dass die Wetter ihre ganze Lebhaftigkeit wieder erlangen.

In this case the miner can only look upon his subterranean passages as pipes of large but irregular internal dimensions, and as it is these very irregularities which he seeks to thoroughly ventilate and keep free from foulness of all kinds, he will hesitate before introducing a manufactured pipe which, instead of easing, will increase his cares.

The real remedy here is larger air-ways, improved stoppings in the holings between the intake and return air currents, and a higher ventilating power.

In the mine the galleries form the natural channels through which to conduct the air, and to lay a large pipe along any of them would simply be an impediment to the ventilation. Less power and less expense will pass many times more air through these galleries and to all places where it is wanted than could be conveyed through any series of pipes. That want of air in gaseous mines too often results in explosion no one will attempt to gainsay, but to supply air through pipes into the workings must necessarily hinder the air from passing in its proper channel and so increase the risk under this head, consequently be the cause of more explosions.

Mining engineers have not as a rule been slow to avail themselves of the assistance of pipes to draw gas out instead of allowing it to mix with the ventilation of the mine wherever it could be confined so as to rise to the surface. There are several instances of this having been done in the Northern Coal-field, one of which, with its long forky flame, must have been seen by thousands of the travelling public when crossing the Victoria Viaduct between Pensher and Washington Railway stations. This is at the North Biddick Pit. Economists may also be glad to learn that the talented manager of that colliery utilizes this gas by day to assist in raising steam for the pit's use, and by night to throw a light around the establishment, which light may be seen as described above.

CHAPTER IX.

SUMMARY AND SUGGESTIONS.

UNLESS there be a full and regular current of fresh air circulating in all passages of mines evolving explosive gas they will be worked at risk and subject to explosions. It is, however, within reach of our knowledge how to apply means if not to entirely destroy the insidious gas, so to reduce its vitality as to render it practically harmless.

The remainder of this treatise will be devoted to this important question.

From reports by various Parliamentary Committees and statistics from the reports of Her Majesty's Inspectors of Mines, the writer has constructed the diagram Plate IX. The information for the earlier part of the century is somewhat imperfect compared with the accurate figures which can now be obtained from the annual returns of the Inspectors.

As fundamental points for the first half of the century on the diagram, the writer has availed himself of the information given in the Select Committee's Report of 1835 and 1849, and of Professor Phillips's Report, 1850. For the subsequent period the information is taken from the Inspectors' Reports.

From 1835 to 1852 it will be observed that the improvements in ventilation appear to have kept pace with the production of coal. From 1852 until towards the close of the sixth decade even to the present time, the production of coal has augmented almost uniformly, but it is not so with the ventilation. There is a feebleness to be observed from 1852 until about the middle of the seventh decade, when the re-introduction of mechanical ventilation gives the curve a very rapid upward tendency until it reaches the bar of 1879, showing the air curve exceeding that of the production of coal. These curved lines are not co-ordinate.

Inversely to the line of ventilation, if we take the average number of explosions from 1850 to the end of 1879, a decrease of about 34 per cent. will be found, whilst over the same period the power of ventilation has more than doubled. Hence the writer submits that the best of the known means for obtaining an efficient ventilation has not in all cases been applied to the prevention of explosions.

Another serious lesson to be learnt from the diagram is that the average deaths to each explosion during the last thirty years has risen about 33 per cent. Taking this fact inversely to the reduction in the number of explosions, it points very significantly to the increased desolation which will find place at the unfortunate concerns where this dread enemy to coal mining is permitted to assert its dominion.

That explosions in collieries may be entirely prevented is more than the most sanguine can expect. That they may be arrested is as certain as there is a limit to the discharge of the explosive mixture. Explosions do not generally occur at blowers, although it is possible they may arise from that cause. Explosions arising from accumulations of gas can be prevented, as these accumulations can be swept out, if not entirely from the goaves yet to such an extent as to render what remains in the higher reaches practically harmless. That gas directly from a blower, if coming within reach of an unprotected light, will burn, is also as certain as that a jet from a gasometer will burn under similar circumstances, but if there be an abundance of air to subdue and reduce the gas below the point of explosiveness, the flame will remain at the point or locality of its ignition precisely as a lighted jet from a gasometer would do. This would give the workmen time to extinguish the flame, or even to send for the manager, who before any dangerous consequences ensued would be able to assemble his staff and apply the means for smothering the flame, which is generally done by sealing the fire up with stoppings.

Until the time arrives when colliery explosions may be spoken of as calamities of the past the great question is, "What can be done to prevent, or at least lessen, the sacrifice of life now attending them?" This question comes home to all who have collieries evolving gas, and where there is the slightest accumulation of it. The solution has been given in the last chapter. The necessity of larger air-ways to reduce the friction and high velocity of the currents, greater care in building stoppings and keeping them tight to ensure a perfect separation between the intake and return air courses, and the application of the best-known ventilating power cannot be too strongly urged upon the attention of engineers and managers. Yet in addition to these primary requirements there are numerous minor arrangements or provisions which perhaps have not been thought of until after the fatal hour. More victims fall by the deadly after-damp than by the blast of the explosion. Could the ventilation be speedily restored after the blast there is no doubt that many lives would be saved and valuable information as to the cause of the explosion might be obtained from the rescued. The speedy restoration of the air current would, however, depend very much upon the arrangements made in opening the mine.

With a few examples of such the author will conclude his work.

Next to stoppings, which have already been noticed, the most important work in connection with the separation of the fresh from the return air-courses is the making and placing of the doors. Doors must be strongly made, at the same time as light as possible, so as to offer the least resistance to an explosion, and be placed as nearly air-tight as possible. In the operations of the mine few doors as practicable ought to be applied. When these doors are not used for underground mineral traffic they will be best hinged from the top bar of the frame. They ought not to be set vertically but at an angle of about 75 degrees. (See Plate X.) This will effectually ensure their closing and remaining so.

In cases where the main separation doors give the shortest passage between the shafts they ought to be in duplicate, as shown in Plate V. Separation doors to the waste ought not to be locked, the passage ought to be fenced, and one moving bar of the fence made to lock.

Air-crossings come next in importance to the separation doors. The main crossings are best driven in solid strata over or under the main ways, or where this is not practicable they ought to be made of solid masonry. The under side of the arch ought to be in line with the roof, and the side walls; if carried out beyond the coal wall, ought to be slowly returned back to it, so that in case of an explosion there will be as little projecting surface of the masonry as possible for it to strike against. There ought to be ample area on the top of the arch, and full provision made to avoid all projections of masonry which might be struck by a blast of an explosion. The summit of the arch ought to be attained by a long sloping causeway.

The innermost crossings of any district ought to be made with a view to localize the force of any explosion which might occur. An arched crossing of masonry may not be the best to meet such a contingency, because the same argument holds good in the case of such air-crossings as in doors. The less an explosion is confined the less will be the damage and extent of its ravages, therefore to minimize the force of an explosion resistance of all kinds ought to be reduced to a minimum. The best design which the author has seen of a crossing to meet such an accident is that introduced at Thornley Colliery in the year 1841, an illustration and description of which appeared in Professor Phillips' Report on the Ventilation of Collieries in 1850. This description is added as an Appendix, and the illustration forms Plate XI. of the present paper.

CONCLUSION.

THE future safety and well-being of a colliery depends almost entirely upon its proper commencement, perhaps more so than any other industrial establishment. Where we find one colliery well laid out, how many are there which require only a glance, even from the non-professional eye, to see how very far they are from that standard from which the capitalist and workmen might congratulate themselves as upon a mutual benefit. The evil of a mal-arrangement does not stop at simple unprofitableness in the working but often ends in absolute abandonment, which brings heavy loss to the capitalist, temporary privation to the employées, and perhaps ruin to the small enterprising tradesman who has erected a shop and dwelling in the locality. But sad as is this aspect, it is light compared to the day-by-day existence of the badly-arranged and badly-worked colliery which can only be carried on at great extra expense for labour and other charges out of all proportion to the quantity of coal produced. The true aim of management must be to reduce all expenses between the raw producer and the consumer: profit in its broadest meaning is the attendant to safety —therefore, the forwarding of the increase of the hewers' labour in the safest and most expeditious manner is, and must be, the duty of all other employées.

Outlay in working a top-heavy, badly-arranged concern puts out of the question not only any redemption of the original capital but also renders necessary such a low scale of wages as only the poorest class of workmen will accept, and these are chiefly the offcast from better-arranged establishments, and are mostly illiterate and disreputable characters, thoroughly reckless and ignorant, and whose very looks stamp the place with an appearance of insecurity. Accidents from every conceivable cause constantly follow in the wake of such a class of men, and especially under such arrangements as described.

How different would be the case with a colliery well laid out and well ventilated can be readily imagined and need not here be further alluded to. Something should, however, be done to enforce the adoption of the best and safest mode of laying out and working every colliery, and which would always prove the most economical in the end. But whilst in our towns the smallest cottage cannot be erected until the plans have been passed by the local authorities, and the smallest craft built in our docks must not leave the harbour to trade until its fitness has been ascertained; the very serious responsibility of opening out a coal-mine remains uncontrolled. This liberty to open coal-mines indiscriminately is not taken advantage of by the coal-owner proper to do anything imperfectly or work at the slightest risk. He knows, perhaps too well, that interest and redemption of his capital can only be obtained by having everything about his colliery properly established and well ordered. But this freedom of opening collieries admits a new class of speculator who is not a "colliery-owner," and whose only thought is how to obtain a large dividend. There are of course exceptions even in this class.

APPENDIX.

NOTE A.—PLATE XI.

THORNLEY COLLIERY,
MARCH 15TH, 1850.

DEAR SIR,—The plan of my valve air-crossing you will receive with this, which I trust you will readily understand. I have no hope of it (made of wood) withstanding the enormous force of heavy explosions; but as we find the majority of explosions are not of the most powerful kind, it is to be hoped that it may be of service in preventing the great delay so frequently experienced at crossings, in attempting to restore the ventilation after explosions of the less dreadful description, which delays are no doubt the cause of a great many deaths. I believe that had such a crossing (feeble as it may be considered) been in use where the accident happened some 12 or 14 years ago (which led me to think of it), a less sacrifice of life would have taken place than did at that time. This crossing, I regret to say, was too soon tested after its first erection in the Harvey seam at this colliery, where nine lives (the only lives lost under my charge by explosion) were lost. On that occasion there was, however, a degree of comfort left to me in the thought, that at this crossing (the only crossing in the pit) there was not one moment of detention, and that possibly some lives were saved by it. I think the only more perfect crossing than this, in use, is that formed by a drift overlapping the fresh air-drift, such as I pointed out to you in our High Main seam at this colliery, but it is not always convenient to have such crossings, as a strong roof to form them is required. I have thought that a metal tube, put together in segments, might make a good air-crossing, if the expense were not too great.

I remain, &c.,
Your obedient servant,
R. HECKELS.

Professor Phillips, York.

NOTE B.—WATER GAUGES.—PLATE XII.

Water gauges as now made and supplied to the trade are much too expensive and very brittle, which may be some reason why more of these useful little instruments are not in use. The author has given some thought to their construction, and gives a sketch of two (see Plate XII.) As shown, they have their frames of cast brass, and ordinary steam boiler gauge glasses inserted. Between the glasses a strip of wood is screwed from the back upon the front of the frame, and the scale is screwed to this piece of wood. In cost these gauges are much less than those now in general use. The great advantage is in their strength, and in the event of breakage of the glasses in the small cost at which they can be repaired. Fig. 1 is adapted so that the gauge may be placed against a wall at any convenient place a short distance away from the point of gauging the pressure; as, for instance, it could be placed in the engine-house, and attached by the nozzle to an India-rubber tube or lead piping leading to any part of a fan case or air passage. India-rubber washers are placed in the sockets at the ends of the glass tubes, which are tightened by the screwed caps on the top, upon one of which the nozzle is formed.

The gauge, as shown in Fig. 2, is cast in one piece, and is without the screwed caps on the top. The glass tubes are about $\frac{3}{4}$ inch longer than the distance between F and G (Figs. 2 and 3), and they are placed in the following manner:—The tube is inserted diagonally (as shown in dotted lines, Fig. 3) from the front side, and pushed up free from the bottom socket and dropped down into position as shown in the full section, Fig. 3. Fig. 4 is a sectional plan of the bottom sockets. The space round about the ends of the tubes is equalized and packed in with putty or cement, and this answers equally well in making tight as the India-rubber washers used in the gauge No. 1. The scales are fixed in the same manner as No. 1, and they are chamfered on the edges of the hinder side so that the divisions can almost be made to touch the glass tubes.

The first gauges of this kind which the author had made were constructed of sheet brass, about 1-16th of an inch in thickness. It was in two distinct pieces, the top being separate from the bottom, and they were accurately screwed on to a piece of dressed deal.

Another advantage of these gauges is the method of applying the scale, which is divided into 20 to an inch, reading up and down from the centre. To prove the adjustment of the instrument relieve it of the pressure, and if the water is level by the centre on the pressure being reapplied either the upper or lower surface will give the reading direct in inches or fractions of an inch.

To make an accurate observation of the pressure, should the water-level not stand correctly at zero on proving the instrument, the mean of the two readings must be taken. Thus in Fig. 1 the water, when free from pressure, has been slightly above zero, but under pressure what was almost imperceptible becomes a readable quantity: in the high column we read 2·6; in the low column 2·5, the mean of which is 2·55, and the same result would have been obtained had the water been considerably above or below zero: thus had it been 0·55 below zero, the upper level when under pressure would have read 2, and the lower 3·10, the mean of which is 2·55. These results can be proved by adding or subtracting, as the case requires, depending upon whether the water when free from pressure is above or below the zero line.

The lines *a a*, *b b*, refer to the first reading, and *c c*, *d d*, to the second (Fig. 1). Whenever the *utmost* precision is required it will be found advisable to take the mean of two readings, and as it is easy to observe the half-twentieth ($\frac{1}{40}$th) of an inch, readings of this water-gauge become quite practicable to the $\frac{1}{200}$th part of an inch by the naked eye. Thus if we take the markings, as shown on Fig. 2 on the lower column, we have 2·56 and the upper 2·53 = $\frac{309}{2}$ = 2·545, the third place of decimals being $\frac{5}{1000}$th or $\frac{1}{200}$th part of an inch, a degree of accuracy which the author thinks has never been obtained in water-gauge reading.

Water-gauges of ordinary construction, placed in the separation in the vicinity of ventilators of the varying capacity class, are subject to very rapid changes. With a Lemielle each wing, as it passes the orifice of the return air-way into the fan case, gives a rapid elevation to the water gauge, followed by an immediate fall, to be taken up again by the next following wing; such a machine going at 20 revolutions per minute with its three wings gives a change of half-an-inch, or more, each second of time. Observations made under such circumstances evidently cannot be much better than approximations.

The rapid rise and fall of the water can, however, be regulated and reduced almost to nil by the gauges just now described by simply inserting a thin copper disc, having a small hole perforated in the centre, at the bottom of either of the glass tubes and over the orifice connecting the two tubes in the casting.

In 1873 the author was interested in making some experiments with a Lemielle ventilator, but owing to the fluctuations of the column in the ordinary water-gauges, a correct reading could not be obtained; to overcome the inconvenience he had one specially constructed of wood, in box form, 12 inches by 12 inches, with a partition down the middle, and 6 inches deep; to insure tightness it was done inside and outside with hot pitch. When finished the partitions for water column were about 5 inches square inside, and the orifice connecting them at the bottom was about $\frac{1}{8}$th of an inch, or $\frac{1}{1600}$th of the area of the surface of either column; this practically gave a still calm surface. The partitions were separately glazed, and an ordinary 12-inch plotting scale (20 to an inch) was placed down the front side, covering the division between the partition. This water gauge, although of rather primitive construction, answered its purpose most admirably.

NOTE C.

Copy of Rule written in the front part of the book kept in the engine-house for recording the work done by the ventilating machine:—

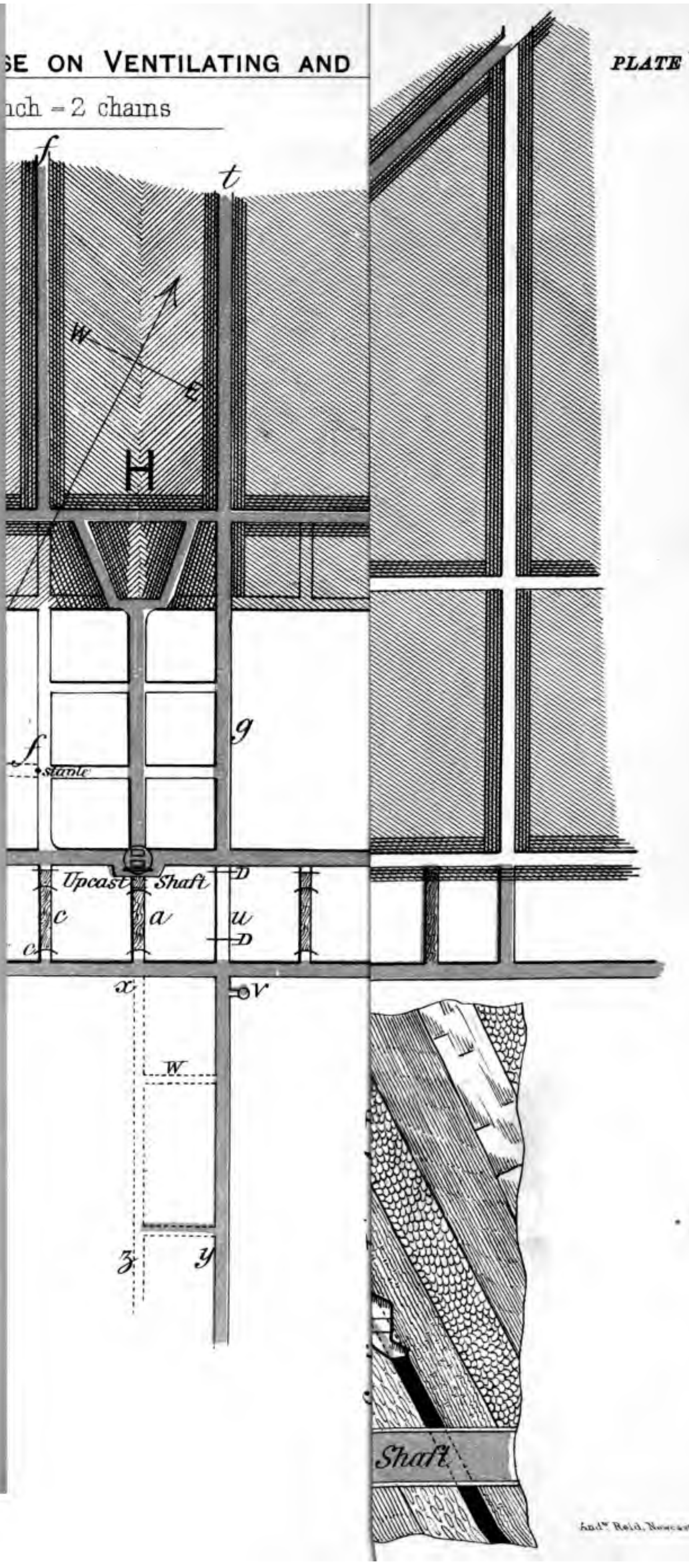
ORDER.

The fan must never be stopped without the cognizance of the manager and underlooker, who must have full

SE ON VENTILATING AND

PLATE V

nch = 2 chains



Andw. Reid, Newcastle.

knowledge of time of stopping, and the probable duration of the stop, and after the recommencement of the fan they must give an order as to the speed the ventilator is to run at for a stated time; this special extra speed to make up for lost time.

On the expiration of the time of extra speed the engineman will gradually reduce the speed of the ventilator until the average normal speed is attained.

The engineer must enter the cause of stoppage in the current entries of the book.

(Signed)

Note E.

The following Rule was written in front of the book carried by the person whose duty it was to measure the air:—

RULE FOR MEASURING THE AIR.

Sectional area to be entered at the time of each measurement: height × width = area.

The person measuring must hold the anemometer at arm's length in front of his body, and keep the face of the fan square to the current of the air, and keep moving it slowly as per the dotted line drawn within the figure below.

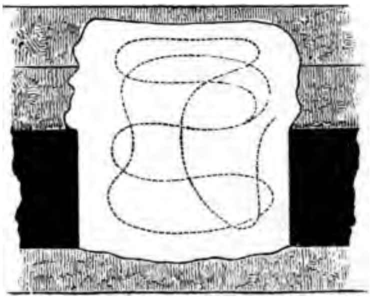


Fig. showing section of a place at which the air is measured, the dotted line to illustrate movements made by the anemometer.

The index figures of the anemometer to be entered continuously:—

1.—Take the velocity for one minute, and make complete entry.

2.—Take the velocity for two minutes and divide by two; should the average be near the first reading, enter the average as the velocity.

In all cases add or subtract, as the case requires, the correction due to the instrument.

One page to be used for each measurement. Date and time of day must always be written at the top of the page, and the person measuring to sign his name at last measurement.

(Signed)

ICE FOR RECORDING THE VENTILATION.

———— COLLIERY, FEBRUARY, 1880.

AT A POINT MARKED *B* ON THE PLAN.
Intake of the West Side of VI. Seam.

e of ea- ing.	Nearest Water Gauge.	DIMENSIONS OF THE AIR-WAY. Height.	Width.	Area.	Velocity of Air in Feet per Minute.	Cubic Feet per Minute.
		Feet.	Feet.	Feet.		
..	...	5·0	6·0	30	460	13,800
..	...	5·0	6·0	30	340	10,200
..	...	5·0	5·5	27·5	472	12,980
..	...	5·5	5·0	27·5	445	12,237
..	...	5·5	5·0	27·5	407	11,192

AT A POINT MARKED *C* ON THE PLAN.
Main Intake of the East Side of VI. Seam.

Time of Mea-suring.	Nearest Water Gauge.	DIMENSIONS OF THE AIR-WAY. Height.	Width.	Area.	Velocity of Air in Feet per Minute.	Cubic Feet per Minute.
		Feet.	Feet.	Feet.		
...	...	5·0	5·0	25	470	11,750
...	...	5·0	5·0	25	420	10,500
...	...	4·5	5·0	22·5	802	18,000
...	...	4·5	6·0	27	730	19,710
...	...	6·0	9·0	54	367	19,818

AT A POINT MARKED *E* ON THE PLAN.
Main Intake of VII. Seam.

..	...	5·0	6·5	32·5	930	30,225
..	...	5·0	6·5	32·5	720	23,400
..	...	5·75	6·75	39·0	630	24,570
..	...	3·5	5·5	19·25	1,260	24,225
..	...	5·75	6·75	39·0	675	26,325

AT A POINT MARKED *F* ON THE PLAN.
Intake of VII. Seam.

...	...	3·0	4·5	13·5	1,000	13,500
...	...	3·0	4·5	13·5	540	6,090
...	...	3·0	4·5	13·5	660	8,910
...	...	3·0	3·0	9·0	550	4,950
...	...	3·0	4·6	13·5	555	7,492

AT A POINT MARKED *H* ON THE PLAN.
Return of VI. Seam.

..	...	6·0	5·5	33	390	12,870
..	...	6·0	5·5	33	300	9,900
..	...	6·0	5·5	33	387	12,771
..	...	6·5	6·5	42	710	29,810
..	...	6·0	5·5	33	412	13,596

AT A POINT MARKED *I* ON THE PLAN.
Return in VI. Seam.

...	...	...	...	40	720	28,800
...	...	...	...	40	510	20,400
...	...	...	...	40	405	16,200
...	...	...	...	40	395	15,800
...	...	...	...	40	350	14,000

Within the innermost thirling of the East Side in VI. Seam.

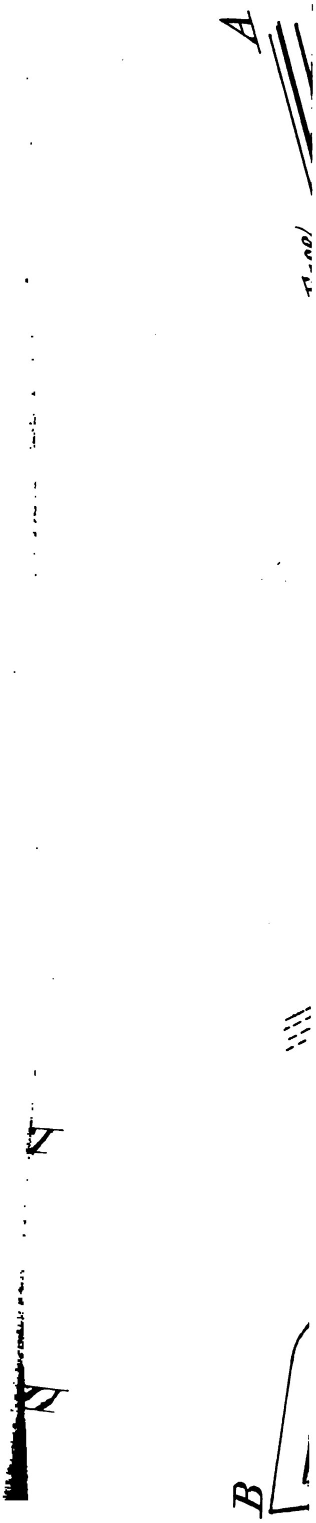
.	...	4·3	4·10	20·5	70	1,435
.	...	4·3	4·10	20·5	60	1,230
.	...	4·3	4·10	20·5	75	1,537
.	...	4·3	5·3	22·3	50	1,115
.	...	4·3	5·3	22·3	90	2,007

...	...	...	...	...	...	...
...	...	...	...	...	...	...
...	...	...	...	...	...	...
...	...	...	...	...	...	...
...	...	...	...	...	...	...

s to fill in, in writing, as shewn in *italic* in the top column.

AND WORKING

AND WORKING



ANDREW REID,

Printer and Publisher.

WORKS: PRINTING COURT BUILDINGS, AKENSIDE HILL.

BRANCH: 12, COLLINGWOOD STREET.

TRANSACTIONS OF THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS, with numerous Illustrations. Royal 8vo., half-calf. Price 21s. Vol. XXIII. is 26s. (The whole of the 30 Vols. can be had excepting Vols. III., IV., V., and VI., which are out of print.)

ILLUSTRATIONS OF FOSSIL PLANTS. Royal 8vo. An Autotype reproduction of 64 SELECTED DRAWINGS of Fossil Plants, prepared under the direction of the late Dr. LINDLEY and Mr. W. HUTTON. Price 25s.; Post Free 26s.

CATALOGUE OF THE HUTTON COLLECTION OF FOSSIL PLANTS. Royal 8vo. Price 8s.; Post Free 8s. 4d.

AN ACCOUNT OF THE STRATA OF NORTHUMBERLAND AND DURHAM, as proved by Borings and Sinkings. Vol. I., A to B, 293 pages, Royal 8vo. Price 7s. 6d.; Post Free 8s. Also Vol. II., C to E, 331 pages, 7s. 6d.; by Post 8s.

TRANSACTIONS OF THE NEWCASTLE-ON-TYNE CHEMICAL SOCIETY. Vols. I., II.. III., and IV. Demy 8vo. 10s. each. Vols. I. and II. out of print.

TRANSACTIONS OF THE COLLIERY ENGINEERS. Vols. I., II., and III. Demy 8vo. Price 5s.; Post Free 5s. 3d.

TREATISE ON MINE VENTILATION. By the late J. J. ATKINSON, Esq., Government Inspector of Mines. *(7th Thousand.)* Price 2s.; Post Free 2s. 1d.

THE VENTILATING AND WORKING OF COLLIERIES. By J. A. RAMSAY. Royal 8vo. Numerous Coloured Plates and Diagrams. Price 5s.; Post Free, 5s. 3d.

THE INDUSTRIAL RESOURCES OF THE TYNE, WEAR, AND TEES. Price 10s. Illustrated.

THE RIVER TYNE: ITS HISTORY AND RESOURCES. By the late MR. JAMES GUTHRIE, Secretary of the River Tyne Commission. Demy 8vo. with numerous Illustrations. Price 10s. 6d., or by Post 11s. 2d.

HINTS TO STEAMSHIP OWNERS. By a CONSULTING ENGINEER. Price 1s.; Post Free 1s. 1d.

THE ROMAN WALL. By Dr. BRUCE. 3rd Edition. Royal 4to., splendidly Illustrated. Published at £3 13s. 6d. Folio, Seven Guineas. (Out of print.

GUIDE TO THE ROMAN WALL (WALLET BOOK). By Dr. BRUCE. Crown 8vo. Illustrated. Price 5s.; Post Free 5s. 3d.

THE LAPIDARIUM SEPTENTRIONALE. By Dr. BRUCE. Folio. Splendidly Illustrated. Published at Seven Guineas. (Out of Print.)

PLAN OF THE NORTH WALES COAL FIELD. By J. B. GREGORY and J. PRICE. On Rollers, Mounted and Varnished, 30s.; in Case, 12 by 9 in., 25s. each.

NEW PLAN OF NEWCASTLE-UPON-TYNE AND GATESHEAD. Reduced from the Actual Surveys of the Borough Engineer. Small Pocket Plan, 6 in. to the mile, in Case 1s. Second Size, 8 in. to the mile, Sheets 7s. 6d.; Mounted, Varnished, and on Rollers, or in Case, 15s.; Coloured, showing the Parishes, 21s. Largest Size, 12 in. to the mile, Sheets, 15s.; Mounted on Rollers or in Case, 31s. 6d.; Coloured, showing the Parishes, 42s. (1879.)

PLAN OF THE COAL SEAMS OF NORTHUMBERLAND AND DURHAM COAL FIELD. By J. B. SIMPSON, Esq., Mining Engineer. On Rollers or in Case, 21s.

GEOLOGICAL MAP OF THE COUNTY OF NORTHUMBERLAND. By G. A. LEBOUR, F.R.G.S. Size, 30 by 22 in. Price, in Sheets, 6s.; in Case or on Rollers, Mounted and Varnished, 10s. 6d.

MAP OF THE RIVER TYNE. 3rd Edition. On Rollers or in Case. 5s. (Reduced from the Actual Survey by J. F. URE, Esq.) Post Free 5s. 3d.

PAST EVENTS. A Record of Important Events of Local and General Interest which occurred during the Years 1879-80. Vols. I. and II. Price 1s. 3d. each.

HAND-BOOK TO NEWCASTLE. Illustrated. Price 5s. Out of print.

HAND-BOOK TO NEWCASTLE. By Dr. BRUCE. Price 1s.; Post Free 1s. 1½d.

SEVEN DAYS IN LONDON. A Practical Descriptive Guide to London.—A Map for each day. Price, 1s.; Post Free, 1s. 1½d.; or bound in Cloth, 2s.; by Post, 2s. 2d. *(10th Thousand.)*

A DAY IN NEWCASTLE. Price 4d.; Post Free 4½d.

REID'S POCKET DIARY (Monthly). Price 1d.; Post Free 1½d. Established 13 Years.

REID'S RAILWAY GUIDE (Monthly). Price 2d.; Post Free 3d. Established 32 Years.

DEDICATED BY PERMISSION TO

JOSEPH WHITWELL PEASE, ESQ., M.P.

NOW READY, ROYAL 8VO, 66 PP.,

WITH

Numerous Coloured Plates and Diagrams,

PRICE 5S.; POST FREE 5S. 3D.,

THE VENTILATING

AND

WORKING OF COLLIERIES,

BY

J. A. RAMSAY,

Littleburn Colliery, near Durham (late of Washington Colliery).

THE object of the Treatise is to present a short Survey, founded mainly on practical instances, of the manner in which a Colliery ought to be laid out with a view of obtaining a safe and profitable working. It is illustrated with Plates and Coloured Diagrams, and will be found a useful Book, not only for Colliery Managers, but also for others interested in Coal Mining. The production and use of Coal being of great popular interest, general readers will find much matter of entertainment, and attention will be sustained by making reference to the Diagrams as the pages of the Book are being perused.

Newcastle-upon-Tyne:
PUBLISHED BY ANDREW REID, PRINTING COURT BUILDINGS.

ANDREW REID, PRINTING COURT BUILDINGS, AKENSIDE HILL,

ENGRAVING

ENGRAVING ON STEEL OR COPPER.

Notes and Cheques, Bonds, Share Certificates,
Receipts, Bills of Exchange and Lading, Invoice Heads,
Visiting, Invitation, and Business Cards, &c., &c.

Door & Window Plates of Brass or Zinc Made & Engraved.

WOOD ENGRAVING EXECUTED BY FIRST-CLASS ARTISTS.

STATIONERY

COMMERCIAL & FANCY STATIONERY
OF EVERY DESCRIPTION.

DRAWING PAPERS AND MATERIALS.

Tracing Cloth and Tracing Paper.

Stationery Cabinets (New Designs) in Oak and Walnut.

COPYING AND SEAL PRESSES.

India Rubber and Brass Endorsing Stamps.

Purses, Pocket Books, Wallets, Tourists' Writing Cases,
Albums, Blotting Books, Card and Letter Cases.

SECTIONAL PAPER AND BOOKS.

OFFICE AND LETTER BASKETS. DEED AND CASH BOXES.

LETTER BALANCES. INKSTANDS.

Andrew Reid will be glad to submit Estimates for any of the different classes of Work carried on by him.

BRANCH: 12, COLLINGWOOD STREET, NEWCASTLE.

ANDREW REID, PRINTING COURT BUILDINGS, AKENSIDE HILL,

To the Coal and Iron Trades.

PIT PAY BILLS,

BOOKS,

FORMS, INVOICES, WAGGON TICKETS,

AND

EVERY DESCRIPTION OF PRINTING

REQUIRED BY

Ironmasters, Colliery Owners, Coal Fitters,

MERCHANTS, AND MANUFACTURERS,

Well Executed, with Despatch and on Reasonable Terms.

MAPS, PLANS,

DIAGRAMS, & ILLUSTRATIONS OF MACHINERY.

ANDREW REID,

PRINTING COURT BUILDINGS,

NEWCASTLE-ON-TYNE.

Special Rules and Abstract of Mines Regulation Act, 1872.

BRANCH: 12, COLLINGWOOD STREET, NEWCASTLE.

ANDREW REID, PRINTING COURT BUILDINGS, AKENSIDE HILL,

LETTERPRESS + PRINTING.

ILLUSTRATED BOOK WORK,

Magazines, Periodicals, Societies' Proceedings,

PAMPHLETS, CATALOGUES,

MEMORANDUM AND ARTICLES OF ASSOCIATION,

LAW FORMS,

JOINT STOCK AND OTHER COMPANIES' FORMS,

AND

All kinds of Commercial Printing.

ACCOUNT BOOK MAKING.

LEDGERS. CASH BOOKS. DAY BOOKS.

LETTER BOOKS,

JOURNALS. INVOICE BOOKS, &c.

BOOK BINDING

IN

Full Morocco, Russia, Calf, Vellum,

BUCKRAM, HALF-BINDING, CLOTH WORK, &c.

LIBRARIES RE-BOUND.

BRANCH: 12, COLLINGWOOD STREET, NEWCASTLE.

ANDREW REID, PRINTING COURT BUILDINGS, AKENSIDE HILL,

DRAWING.

ORIGINAL DESIGNS
MADE FOR
Illustrated Works of every Description.
MAPS, PLANS, DIAGRAMS, & EVERY VARIETY OF PLATES
REQUIRED FOR WORKS CONNECTED WITH THE ARTS AND SCIENCES.
Ornamental Book Covers, Title Pages, Heraldic Drawings,
ILLUMINATED ADDRESSES, &c.

LITHOGRAPHY.

ILLUMINATIONS, CHROMO WORK,
CHALK DRAWINGS,
RAILWAY PLANS AND SECTIONS,
Engineers, Architects, and Surveyors' Plans,
BUILDERS' QUANTITIES, CONTRACTS, & SPECIFICATIONS.
PLANS AND PARTICULARS OF ESTATES.
CIRCULARS, HEADINGS, INVOICES, LETTERS,
AND EVERY DESCRIPTION OF
COMMERCIAL LITHOGRAPHY.

ORNAMENTAL CALENDARS, SHOW CARDS, &c., DESIGNED AND LITHOGRAPHED IN GOLD AND COLOURS.
MANUFACTURERS' PATTERN BOOKS, ILLUSTRATED CATALOGUES,
COLOURED LABELS, &c., &c.

BRANCH: 12, COLLINGWOOD STREET, NEWCASTLE.

BUCKET LEATHER,
HARNESS LEATHER,
LEATHER BELTING,
LEATHER HOSE,
WALRUS AND HIPPO. HIDES,
INDIA RUBBER,
SHEETS, VALVES, WASHERS,
COKE OVEN HOSE,
DELIVERY AND SUCTION HOSE,
STEAM PACKINGS,
BRATTICE CLOTH & AIR TUBING,
GUTTA PERCHA,
SHEETS, PUMP BUCKETS, &c.

GEO. ANGUS & COMPANY,

NEWCASTLE-UPON-TYNE.

ANDREW REID, PRINTING COURT BUILDINGS, AKENSIDE HILL,

ANDREW REID,

PUBLISHER,

Commercial and Artistic Printer,

MANUFACTURING STATIONER,

DRAUGHTSMAN AND ENGRAVER.

DEPARTMENTS.

Publishing.

Account Book Making.

Letterpress Printing.

Lithography.

Engraving.

Drawing.

Die Cutting.

Embossing.

Stationery.

Having a complete Manufacturing Establishment, and all work being done on the Premises under personal supervision, all orders receive careful and prompt attention.

BRANCH: 12, COLLINGWOOD STREET, NEWCASTLE.